International Journal of Information and Computer Science
IJICS Volume 1, Issue 1, April 2012 PP. 1-5
ISSN(online) 2161-5381
ISSN(print) 2161-6450
www.iji-cs.org

Study on Applying Multi-level Fuzzy Evaluation Method to Library Pre-warning Index System

Fang Xu , Xiaopu Jin
[1] School of Society, Soochow University, Suzhou, P.R.China
[2] Library, Xi'an Jiaotong-Liverpool University, Suzhou, P.R.China
nankaixufang@yahoo.cn, hyacinth_yama@y126.com

(Abstract) The author designs the structure of the library Pre-warning index system by referring to the relative standardization both home and abroad. Expert query has been taken to grantee its reliability. Because the library pre-waning index system consists of quantitative and qualitative indexes, the author applies multi-level Fuzzy Evaluation Method to pre-warning index system to calculate the estimation total marks. Considering that different library having distinct problems, the author agrees that the index system should be variable according to the different situation. Therefore great importance is attached to analyze the process of applying the multi-level FEM to the library pre-warning index system.

Keywords: LibQUAL+^{TM}; China Nation Library Performance Evaluation Index System; Library Pre-waning Index System; Multi-level Fuzzy Evaluation Method

1. INTRODUCTION

As an open cultural institution of society, libraries increasingly confront with all kinds of risks such as natural, man-made and hybrid. The infamous Florence flood in 1966 is commonly associated with the importance of disaster preparedness in the consciousness of librarians. Unfortunately, the subsequent decades also witnessed further large-scale library disasters. Examples include fires in Los Angeles Central Library in 1986 and the Academy of Science in Leningrad a year later. Unfortunately, due to further notable disasters the situation of this field became worse in 1990s, the most impressive accident was the IRA (Irish Republican Army) bombing in the city of London in 1992, which affected the commercial fire at Norwich Central Library in 1994. All latter events led to many seminars, meetings and even research projects on the topic [1] in the academic communities both home and abroad.

In the 21st century, the new types of crisis have been emerging, such as economical crisis and data resources protection in the digital environment and so on. For the economic reason, twenty-one librarians at Providence Public Library had been dismissed in 2003 and two libraries in Pennsylvanian and New York had been closed in 2004. Data resource protection includes system security, network security and data backup etc. [2].In view of the devastating effects of these crises, librarians have realized the importance of crisis management in the real sense. Thus it becomes unavoidable research task to strengthen the crisis management education, to cultivate the awareness of preventing disaster, and to design the scientific and effective emergency response mechanisms.

There are some current researches about the types of library crisis [2] [3] [4] [5], library disaster management planning [6], property insurance of library [7], library crisis management [8] [9] [10] [11], and library crisis pre-warning system [12] [13] [14] [15] and so on in academic communities. However, few researchers have paid attention to the pre-warning index system (PWIS). As a matter of fact, pre-warning index system is an important and absolutely necessary part of library crisis pre-warning system. PWIS is the foundation of every crisis management activities. So it has significant theoretic and practical value to construct the index system. Due to the fact that the present and potential library crisis involves various factors, it is a typical comprehensive evaluation. In PWIS, there are quantitative indexes and qualitative indexes. The value of quantitative index can be achieved through library information system and activities while the value of qualitative index will be judged by experts. The latter one is a fuzzy value, so the indexes need non-quantitative fuzzy words to be expressed. Meanwhile, there are some questions lacking of comparison in the index system, so it is difficult to make detailed description by typical mathematics.

Multi-level Fuzzy Evaluation Method (FEM) gives all kinds of index a value on the basis of comprehensiveconsideration and distributes a weight according to the influence degree of different indexes [16]. Adopting multi-level FEM to calculate the library pre-warning indexes can solve the problem of

multi-factor, fuzziness, and subjectivity. It also shed light on solving this kind of problems in other fields.

2. REFERENCES TO RELEVANT RESEARCHES BOTH HOME AND ABROAD

Because the calculating process of pre-warning indexes is a process of evaluating a library, the design of pre-warning index can refer to relevant library evaluation index system.

2.1 Libqual+™ of The Association of Research Libraries of America

LibQUAL+™ is a suite of services that libraries use to solicit, track, understand, and act upon users' opinions of service quality. These services are offered to the library community by the Association of Research Libraries (ARL). More than 500 libraries have participated in LibQUAL+™ [17]. From now on,LibQUAL+™ project group has finished several times investigations successfully in the past nine years. A Chinese version implemented in Hong Kong in the fall of 2007. Currently, the system supports 12 languages. Now the survey in 2010 is being planned. The questionnaire also varied year by year, from eight dimensions and 41 questions in 2000 to three dimensions ） and 22 questions in 2004-2006[18].

2.2 Performance Evaluation Index System of National Library Of China

Performance evaluation index system established by China National Library in 2001 was divided into five parts: resource, basic business, business study, management, and reader service. As a statistic index, resource includes purchasing cost, library houses, collections, librarians, equipments and outlay. Basic business consists of document resource purchasing, document resource machining, and the integration of network resources, database construction and the construction of special topic resources. Business study comprises business intercommunication, research project, research fruits and dissertation etc. Services were operated by survey in order to investigate whether the users are contented [19].

3.CONSTRUCTION OF LIBRARY PRE-WARNING INDEX SYSTEM

3.1 Rules of Library Pre-Warning Index System

PWIS is an important part in the crisis management system. On the basis of it, pre-warning system serves the function of crisis recognizing, diagnosing and pre-warning. The rules for library pre-warning index system (LPWIS) construction are as follows [20]: science rule (according to the goal of library crisis management, revealing the problems existing in the library); comparison rule (indicating the correlation degree between the indexes); sensitivity rule (expressing the crisis degree of library exactly and quickly); combining the quantitative index and the qualitative index rule; and system rule (dealing with the library crisis coordinately).

3.2 Structure of Library Pre-Warning Index System

The authors design the basic structure of LWPIS by referring to standardizations both home and abroad (Table 1).

Table 1 Structure of library pre-warning index system

	dimension	Library Pre-warning index
Quantitative Index	resource	types and number of collections and databases number of computers , back-up and multi-media equipments annual outlay for purchasing number of librarians and specialists number and space of library
	service	times of user training or topic propagandizing every year times of active services (E-mail, fax, push, etc.)every year times of interlibrary loan and full-text delivery every year times of international services every year times developing services for social vulnerable groups every year times of accepting client's complaints every year
	technology	ratio of self-building database in all databases times of being attacked by Hack every year updating frequency of website
Qualitative Index		crisis from public image of society crisis bring out by diseases and plagues crisis bring out by natural disasters crisis bring out by unsound laws and policies crisis bring out by competition from intelligence and consultation institutes

Experts query method has been taken by the author to grantee the reliability of the index system. The indexes in the table 1 are the result of expert selection and analysis of data software.

4.MULTI-LEVEL FEM APPLYED IN LIBRARY PRE-WARNING INDEX SYSTEM

The process of multi-level FEM is as follows: at first dividing the factors into different classes, then making the primary evaluation, and operating the advanced evaluation at last (Figure 1) [21].

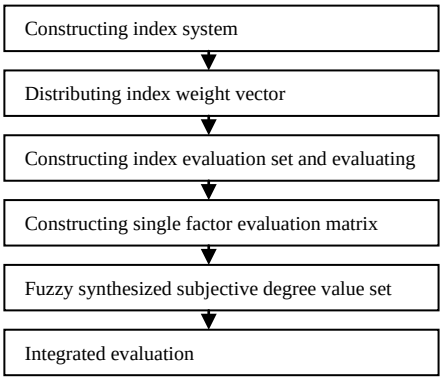

Figure 1. Process of integrated evaluation

4.1 Construction of Fuzzy Evaluation Index Sets

LPWIS (table1) is a multi-factor hierarchical model. Set S consists of two levels. The first level factor is S=（S_1,S_2 ,S_3,S_4）=(resource, service, technology, qualitative index). The second level factor is made up of detailed indexes.

4.2 Distribution Of Index Weight Value

As different indexes have different degree influence on the crisis in PWIS, weight is the yardstick for evaluating the influence. Because the PWIS is a hierarchical structure, we can adopt the AHP (Analytic Hierarchy Process) and geometric mean method to calculate the weight of index:

$$W_k=(W_{k1},W_{k2}\ldots,W_{km}) \text{ and } \sum_{j=1}^{m} w_{kj} =1.$$

AHP put forward by famous operational research professor Sa De in America is a decision method uniting quantitative and qualitative analysis. It is a good way to make human's thinking stratified and quantitified. The step of confirming the weight value can be designed as follows [22]:

Step 1: constructing judgment matrix. AHP turns the complex and out-of-order qualitative questions into quantitative questions by 1-9 marking method in order to confirm the relative importance between two indexes (Table2).

Table 2 Comparison marking definition table

Mark	Meaning
1	A is as important as B.
3	A is less important than B.
5	A is somewhat more important than B.
7	A is clearly more important than B.
9	A is extremely important than B.
2,4,6,8	The middle value between the judgment above and below.
multiplicative inverse	The proportion B and A.

On the assumption that there are pre-warning indexes like C1, C2… Cn, we can judge the relative importance of every index by proportion marking value in table 2. Then we can get a judgment matrix A consisting of relative importance value aij:

$$A=\begin{bmatrix} a_{11} & \ldots & a_{1m} \\ \ldots & \ldots & \ldots \\ a_{n1} & \ldots & a_{nm} \end{bmatrix}.$$

Step 2: Calculating the maximal eigenvalue and eigenvector. It is easy to validate that the eigenvalue of the matrix A is n while the weight vector $\overline{W}$ is the corresponding eigenvector:

$$A\overline{W} = n\overline{W}.$$

The value of W can be computed by geometrical average method. At first, accounting the product of every factor on every line in judgment matrix:

$$m_i = \prod_{j=1}^{n} a_{ij} \quad (i=1,2,3,\ldots,n).$$

Then calculating the n times root: $\overline{w}_i = \sqrt[n]{mi}$;

Thirdly normalizing the vector W=(W_1,W_2,… W_n):

$$W_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}} ;$$

At last gaining the eigenvector: W=(W_1,W_2,… W_n).

Step 3: Verifying coherence. In order to assure the reliability and coherence of judgment matrix and eigenvector, we need verifying coherence by the calculating of coincidence indicator (CI) and coincidence ratio (CR):

$$CI=\frac{\lambda_{max}-n}{n-1}, \quad CR=\frac{\overline{W}}{RI}\frac{CI}{}.$$

The RI is a random coincidence indicator (Table 3). The n is the rank of judgment matrix, namely the number of indexes. The λ_{max} is the maximal eigenvalue of matrix calculating by geometrical average method:

$$\lambda max = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{w_i}$$ i=1,2,…,n; $(Aw)_i$ is the i index of Aw.

Table 3 Value of random coincidence indicator

rank	1	2	3	4	5
RI	0.00	0.00	0.58	0.90	1.12
rank	6	7	8	9	10
RI	1.24	1.34	1.41	1.45	1.49

When the value of CR is less than or equal to 0.10, the judgment matrix has sound consistency. Otherwise the second judgment should be taken for adjusting the elements of judgment matrix until the satisfactory CR is achieved.

4.3 Construction of Index Evaluation Set V, Evluating for μ

The evaluation set V is a direct description or expression for every rank of factor' status. Usually it can be evaluated by rank estimation. The paper uses the five-rank evaluation method: V=(V_1,V_2 ,V_3,V_4,V_5)=(best, better, good, bad, worse). The relevant value for judgment is that: μ = (100, 80, 60, 40, and 20).

4.4 Constrution of Judgment Matrix R

The building up of the judgment matrix is based on the fact measuring. The qualitative index is a fuzzy subjective degree value according to advices from experts. The judgment matrix R is constructed by assessing the subjective degree r_{ij} versus V_j for every factor of S_k, on the basis of the evaluation rank of judgment set:

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}.$$

The r_{ij} is a percentage by comparing the number of people choosing the j rank evaluation for the index i with the whole attended number.

4.5 Computation of Fuzzy Synthesized Subjection Degree Value Set B

Assuming that some class S_k (k=1, 2, 3, 4) have n indexes, we can get the mark of every detailed index by the single factor judgment matrix R_k and evaluation set μ:

$$B_k = R_k * \mu^T.$$

4.6 Integrated Evaluation

On the basis of B_k and index weight W_k, we can gain the evaluation result U_k of this class:

$$U_k = W_k * B_k.$$

Given $B= (U_1, U_2 \ldots, U_n)^T$, repeats the above steps. Treating the four S_k (k=1, 2…, 4) of S as the single factor, we can attribute weight W: $W = (W_1, W_2, W_3, W_4)$ according to the relative importance. At last we can get the integrated evaluation value U of S based on every estimation result U_k （k=1, 2,…,4） of every S_k:

$$U=W*B=W*\begin{bmatrix} U_1 \\ U_2 \\ U_3 \\ U_4 \end{bmatrix}.$$

5 DISCUSSIONS

The author agrees that crisis is an uncertain state in some organization. It is suggested that we usually divide the crisis into five levels by the potential or possible loss during the process of practice. The five levels are excellent, normal, low alarm, middle alarm, and high alarm (Table 4).

Table 4 Crisis rank

rank	L_1	L_2	L_3	L_4	L_5
inter-zone distribution of crisis score	[80, 100)	[60, 80)	[40, 60)	[20, 40)	(0, 20)
level of crisis	excellent	normal	Low alarm	Middle alarm	High alarm

The alertness line is set in accordance with the five levels. The crisis degree set L is $L= (L_1, L_2, L_3, L_4, L_5)$, namely the library has five levels.

The process of pre-warning system is at first calculating the evaluation total score by multi-level FEM, confirming the crisis rank by comparing the evaluation total score to the crisis score inter-zone distributing is closed behind, and finally goes to inform the alarm signal to crisis management group and the potential victims. Because different library having different problems, the author agrees that the index system should be various according different situations. Therefore great importance is attached to analyze the process of applying the multi-level FEM to the LPWIS. However, the further studies should modify the index system and calculate the weight of index taking a given library as an example.

REFERENCES

[1] Adrienne, M., Sarah, S. If the worst happens: the use and effectiveness of disaster plans in libraries and archives [J]. Library Management, 2002,23(3) :p115-123.

[2] Michael, S. The Folk Heritage Collections in Crisis conference. Library Hi Tech. 2001, 19(1):p7-9.

[3] Glen, E. H. Getting beyond the pain: understanding and dealing with declining library funding. The Bottom Line: Managing Library Finances. 2005, 18 (4): p185-190.

[4] Jamie, E. Lessons learned: the recovery of a research collection after Hurricane Katrina. Collection Building. 2007, 26(4):p108–111.

[5] Susan H. Z., Two libraries, one direction. The Bottom Line: Managing Library Finances. 1996, 19 (2):p21–24.

[6] Frank, C. Disaster recovery and continuity planning for digital library. OCLC Systems & Services: International digital library perspectives. 2006, 22 (3):p173-178.

[7] Robert, H. After the disaster: Drawing up the insurance claim. Aslib proceedings. 2003, 5 (3):p181-187.

[8] Luo, X.C. Library crisis management: a two-dimensional framework and its realization [J]. Journal of library science in china.2009, 35 (2):59-64(Ch).

[9] Zhu, T.L. Comparative study of library crisis management in china and foreign country [J]. Researches in library science. 2009 30(6):5-9(Ch).

[10] Yan, H. Case study of domestic library crisis management: the losing of the book donated by BaJin[J]. Library and Information.2008, 29(1):79-83(Ch).

[11] Pao,M. Study on issues on library crisis management[D].Peking University, 2007(Ch).

[12] Fan, X.F., Zhang, X.W. Coping with unexpected events and ensuring library s security: establishing the library crisis early-warning system [J]. Contemporary Library.2009, 38(3):29-31(Ch).

[13] Jin, X.P., Xu, F. Analysis and design of library crisis pre-warning management system [J]. , New technology of library and information service.2008, 24(2):94-98(Ch).

[14] Xu, F. Study on the construction of library crisis pre-warning management system [D]. Tianjin polytechnic university, 2007(Ch).

[15] Jia. C.L. On the disaster management of library consortium [J]. Library journal, 2005,24(11), p11-15, 33(Ch).

[16] Chen, Y.F., Gao, X, et, al. A fuzzy evaluation on flue gas desulphurization technologies[C]. Proceedings of the Chinese Society for Electrical Engineering, 2004, (2): p215-220(Ch).

[17]LibQUAL+™2006survey.http://www.uwe.ac.uk/library/info/about/docs/libqual-report.pdf [EB/OL]. 2009-10-29.

[18] LibQUAL+TM: Defining and Promoting Library Service

Quality [EB/OL].http://www.libqual.org/About/Information/index.cfm.2009.11-24.

[19] Li, Z.Z. About library performance evaluation. Journal of the National Library of China [J]. 2002, 9 (2): p2-5(Ch).

[20] Zhao, X.L., Ma, N. Enterprise crisis analysis and the building up of pre-warning index system [J]. Inquiry into Economic Problems, 2005, 27(8):p73-75(Ch).

[21] Du, D., Pang, Q. H., Wu, Y. Modern comprehensive evaluation methods and case selection [M]. Beijing: Tsinghua University Press, 2008:p35-37(Ch).

[22] Du, D., Pang, Q. H., Wu, Y. Modern comprehensive evaluation methods and case selection [M]. Beijing: Tsinghua University Press, 2008:p12-20(Ch)